



Rockfall along U.S. Route-19 in Monongalia County  
Photo by Morgantown Police Department

# West Virginia Landslide Risk Assessment

## Region 6 – Doddridge, Harrison, Marion, Monongalia, Preston, & Taylor counties

FEBRUARY 10, 2022

In support of FEMA HMGP Project



## Executive Summary

The West Virginia Emergency Management Division (WVEMD), Department of Homeland Security (DHS), and Federal Emergency Management Agency (FEMA) have facilitated landslide susceptibility studies and community-based risk assessments in support of local and state hazard mitigation plans. Landslide susceptibility was modeled using a random forest machine learning method. The model used LiDAR-identified landslide locations, topography, soil type, and proximity to roads and streams among many input variables to produce landslide susceptibility grids. Overall, 3,810 landslide points were identified using LiDAR in Region 6. Risk assessment was performed at the sub-county scale and includes results on roads and structures/parcels. This report summarizes risk assessment results by West Virginia planning and development council regions. Results for Region 6 can be integrated into hazard mitigation plans to enhance resilience and protect communities from landslide hazards.

This landslide risk report provides non-regulatory landslide risk information to help local officials, planners, emergency managers, and others better understand their landslide risk, take steps to mitigate those risks, and communicate those risks to citizens and local businesses.

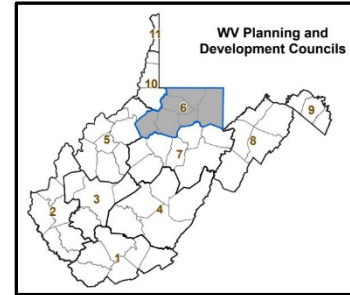
**Road risk analysis** – In Region 6, **Doddridge County** has almost 75 miles of road that is susceptible to high/medium probability of landslides. **Harrison County** has 109 miles, **Marion County** has about 140 miles, **Monongalia County** has 132 miles, **Preston County** has almost 173 miles, and **Taylor County** has about 72 miles of road prone to high/medium risk for slope failure. Counties were ranked for slope failure risk based on the number of at-risk road miles. Three Region 6 counties rank in the Top 10 for highest number of road miles at risk. Of all 55 counties, Doddridge ranks 29<sup>th</sup>, Harrison 13<sup>th</sup>, Marion 7<sup>th</sup>, Monongalia 8<sup>th</sup>, Preston 2<sup>nd</sup>, and Taylor 30<sup>th</sup>. Most of the at-risk roads are in the unincorporated areas of each county.

**Structure/Parcel analysis** - **Doddridge County** has a total of 178 primary structures with a total appraisal value of \$6,739,115 that are in high/medium susceptibility areas. **Harrison County** has 1,069 primary structures with a total appraisal value of \$256,888,640 in high/medium susceptibility areas. **Marion County** has 941 primary structures with a total appraisal value of \$71,733,187 in high/medium susceptibility areas. **Monongalia County** has a total of 2,967 primary structures with a total appraisal value of \$344,409,948 that are in high/medium susceptibility areas. **Preston County** has 277 primary structures with a total appraisal value of \$32,450,262 in high/medium susceptibility areas. **Taylor County** has 373 primary structures with a total appraisal value of \$13,436,410 in high/medium susceptibility areas. Three Region 6 counties rank in the Top 10 for both total structure count and total asset value in high/medium landslide risk areas in the state. For total count of at-risk structures, Doddridge ranks 47<sup>th</sup>, Harrison 4<sup>th</sup>, Marion 6<sup>th</sup>, Monongalia 2<sup>nd</sup>, Preston 37<sup>th</sup>, and Taylor 24<sup>th</sup>. For total asset value, Doddridge ranks 40<sup>th</sup>, Harrison 3<sup>rd</sup>, Marion 5<sup>th</sup>, Monongalia 2<sup>nd</sup>, Preston 12<sup>th</sup>, and Taylor 26<sup>th</sup>.

*This report is for informational purposes related to general emergency services planning. It has not been prepared for, and may not be suitable for legal, design, engineering, or site-preparation purposes. This report cannot substitute for site-specific investigations by qualified practitioners. Landslide risk is complex and continually changing. Although other existing studies or reports may provide more precise and comprehensive information, detailed original site investigations are normally an essential best practice for public safety, sustainability, and financial viability. These other data sources may give results that differ from those in this report.*

## Introduction

West Virginia has been divided into 11 regional and planning development councils to more effectively utilize funding, plan development, and aid cooperation. Landslide risk assessment has been performed in Region 6 for roads and structures/parcels. Roads provide critical service to communities. FEMA recently developed the [community lifelines](#) to enhance their effectiveness in disaster operations and better position themselves to respond to catastrophic incidents. Community lifelines cover seven sectors: Safety and Security; Food, Water, Shelter; Health and Medical; Energy; Communications; Transportation; and Hazardous Material. Roads are classified under Transportation in FEMA community lifelines.



**Figure 1.** Planning and development regions in West Virginia

Landslide risk assessment has been performed to assess high and medium risk road segments and structures/parcels. **This study is suitable for planning-level analysis. The risk analysis for roads should be used in conjunction with site-specific risk analysis performed by WV Department of Transportation.** FEMA's goal is to ensure that communities address natural hazards. A comprehensive plan should acknowledge all hazards that pose a risk and identify steps to avoid these hazards altogether or incrementally reduce a community's exposure to them.

### Community Engagement and Verification:

Review Landslide points identified using LiDAR data in the [WV Landslide Tool](#). Add any missing major landslide points in the web application. A photo of the landslide incident can also be uploaded to the Landslide Tool. Review the susceptibility grid in [WV Landslide](#) or [WV Flood Tool](#). Report any major discrepancies in high/medium landslide susceptible zones.

## About Landslide Risk

Landslides are naturally occurring phenomena that can happen almost everywhere in West Virginia, especially on steep slopes. In its most basic form, a landslide is the movement of soil or rock down a slope. Landslides become hazardous to people and property when they happen in an area where development has occurred, causing losses. Many landslides have relatively little impact on people or property, such as minor road damage, tree throws, or tilting of fences and walls. However, severe landslide damage can topple buildings, destroy roads, disrupt utilities, and cause critical injuries or death.



**Figure 2.** Landslides present a risk to critical infrastructure and public safety (Photo by [WVDOT](#))



## Calculating Landslide Risk

It is not enough to simply identify where landslides may occur. Knowing approximately where a landslide may occur is not the same as understanding the **risk** posed by landslides. The most common method for determining landslide risk, also referred to as vulnerability (the exposure of a given population to harmful effects from a hazard), is to identify the susceptibility of landslide occurrence and then determine the subsequent consequences. In other words:

$$\text{Landslide Risk} = \text{Susceptibility} \times \text{Consequences}$$

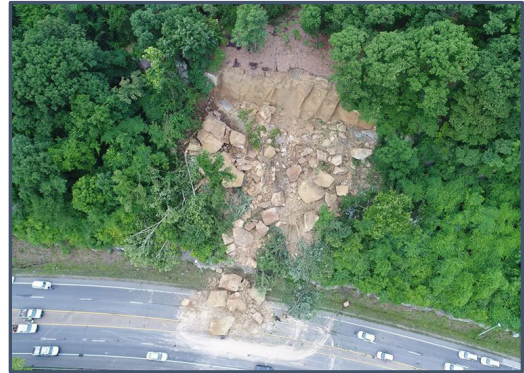
Where,

**Susceptibility** = the likelihood of occurrence

**Consequences** = the estimated impacts associated with the occurrence

An area's **landslide susceptibility** is the likelihood that a landslide will occur. The likelihood of a landslide occurring can change based on physical, environmental, or contributing human factors. Factors affecting the likelihood of landslide occurrence in an area include seasonality, weather, climate, slope, human disturbance, and the existence of mitigation structures. The ability to assess the likelihood of landslide occurrence and the level of accuracy for that assessment are enhanced by landslide modeling methodology advancements and more widespread reporting or mapping of landslide occurrence.

The **consequences of a landslide** are the estimated impacts related to the landslide occurrence. Consequences relate to human activities within an area and how a landslide impacts natural and manmade infrastructures.



**Figure 3.** The **consequences** of a landslide are often higher in populated areas due to resulting property damage and injury to citizens (Photo by [WVDOT](#))

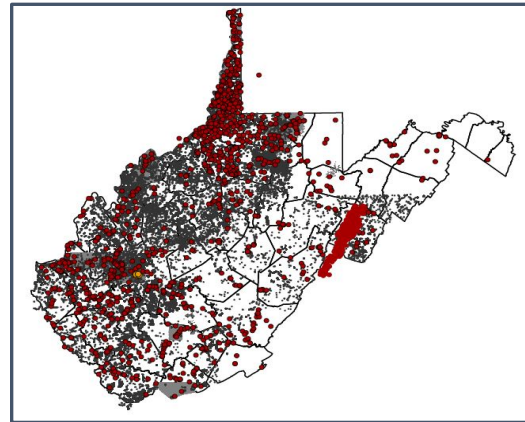
## Sources of Data for Landslide Risk Assessments

To assess potential community losses or the consequences portion of the “risk equation”, the following data is typically collected for analysis and inclusion in a landslide risk project:

- Locations of past landslide occurrence
- Areas susceptible to landslide occurrence
- Information about local assets or resources at risk from landslide occurrence
- Information about where the risk is most severe

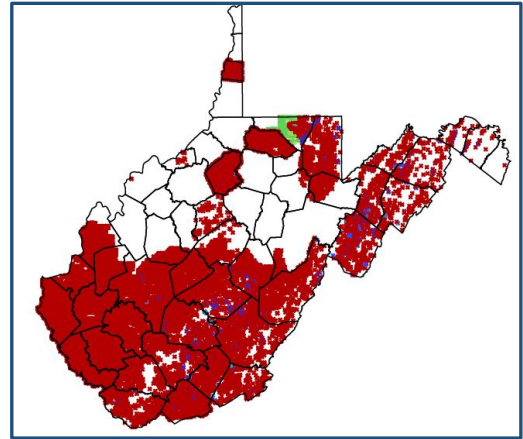
The following sources of incidence information were compiled for the statewide Landslide Risk Project and can be viewed on the [West Virginia Landslide Tool](#). A detailed table showing landslide points and polygons collected in the state can be reviewed [here](#). However, **only high-resolution LiDAR-identified landslide incidence points were used for susceptibility modeling.**

- WVGES Study** - A study by West Virginia Geological and Economic Survey in the 1970s led to a report by Lessing et al. (1976) published as WVGES Environmental Geology Bulletin no. 15. The study mapped 46,330 landslide polygons in 39 7.5-minute quadrangles throughout West Virginia. The study was largely based on air photos taken in the 1960s and 1970s. The [West Virginia GIS Technical Center](#) (WVGISTC) digitized many of these polygons in 2018. Failures were categorized into three broad categories based on original map symbology: older landslides, recent landslides, and rockfalls. Mapping efforts yielded 5,461 landslide polygons from Region 6.
- USGS Study** - The United States Geological Survey completed a multiple-author study between 1975 and 1985 that mapped various failures over 382 7.5-minute quadrangles. The [WVGISTC](#) digitized 41,307 “active or recently active” slope failure polygons in 2018. Mapping efforts yielded 8,361 polygons from Region 6.
- Landers and Smosna (1973)** evaluated the damage caused by flooding and slope failure during a 1973 storm event in Kanawha City. From this study, ten landslide points were mapped in the Charleston area.
- Jacobson et al. (1993)** mapped 3,571 slope failures near the Wills Mountain anticline to evaluate the effects of the November 1985 flood in the upper Potomac and Cheat basins.
- Kory Konsoer (2008) and Beau Downing (2008)**, as part of their M.S. theses, performed a landslide study in the Horseshoe Run watershed in Tucker County, WV. This research mapped 149 landslide polygons within the watershed and included a statistical analysis to quantitatively assess risk. In 2014, **Yates and Kite** created a landslide inventory in the Bluestone National Scenic River and vicinity. Following this analysis, an inventory of 212 polygons was created for the New River Gorge National River area by the same authors (Yates and Kite, 2016).
- West Virginia Department of Transportation (WVDOT) database of landslide locations** – The road landslide Inventory (2016) contains 1,406 points where landslides have occurred along roadways. Many of these incident points are no longer visible with LiDAR data, even at the 1-meter scale, either because they are small enough to escape visibility or because the WVDOT has repaired the damage. The database contains 198 landslide points in Region 6 counties.



**Figure 4.** [Historical landslides](#) were compiled from several studies to create a comprehensive landslide dataset (Image adapted from the [West Virginia Landslide Tool](#))

- High-resolution LiDAR-identified landslide incidence points** - Landslide initiation points were identified and mapped specifically for this project on DEMs created from recent high resolution (1- or 2-m) LiDAR. Trained technicians placed points at the approximate center of the landslide headscarp and classified the failures into one of six general slope failure categories: slide, debris flow, lateral spread, multiple failures, fall, or undetermined. The details of classification can be found [here](#). The nature of the West Virginia landscape and the LiDAR imagery limited mapping to landslides at least 33 feet wide. This approach undercounts small, shallow landslides and slope failures that human agents may have mitigated or removed. Rockfalls, a major landslide risk along roadways, are considerably undercounted in this approach. Overall, 3,810 landslide points were identified in Region 6.

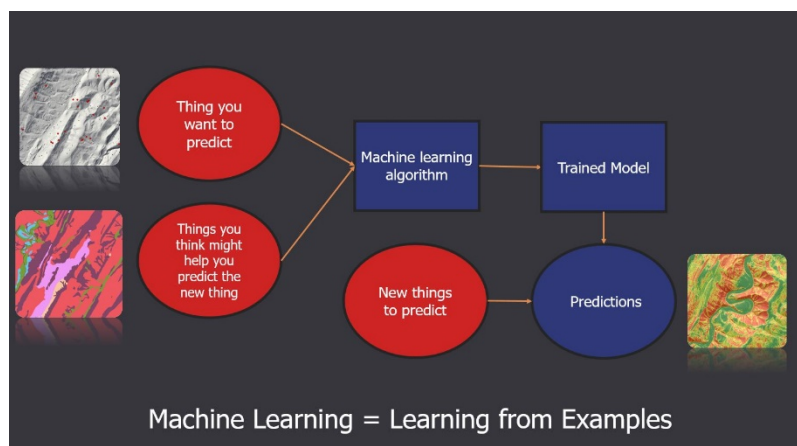


**Figure 5.** [LiDAR-mapped landslide points](#) are dependent upon the presence of 1- or 2-meter LiDAR data (Image from the [West Virginia Landslide Tool](#))

## Landslide Susceptibility Methodology

[Landslide susceptibility](#) has been generated as a grid raster dataset for the state. Much like the pixels in a photo or graphic, a grid is made up of square cells, where each grid cell stores a value representing a landslide susceptibility value. Using Random Forest machine learning methods, landslide incidence was modelled and rendered as a raster grid dataset. In machine learning, a model is generated by learning from examples. Figure 6 shows a simplified diagram of the machine learning model. Modeling starts with two basic variables:

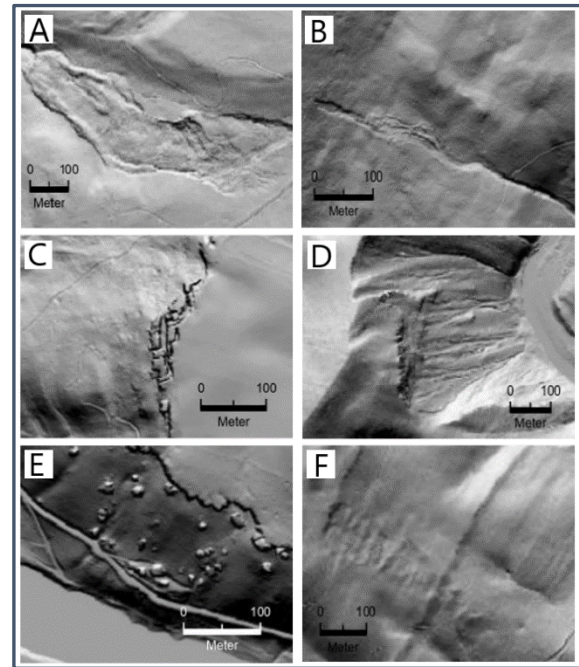
- 1) Response variable you want to predict (example: landslide susceptibility) and,
  - 2) Predictor variables you think might help you predict the new response variable (for example: prior locations of landslide, geology, soil, slope, etc.).
- Then, these predictor variables are run through a machine learning algorithm to train a model. This trained model is used for making predictions. In the end, a new prediction grid is generated (in this case, landslide susceptibility grid).



**Figure 6.** Simplified diagram showing machine learning process for generating landslide susceptibility grid

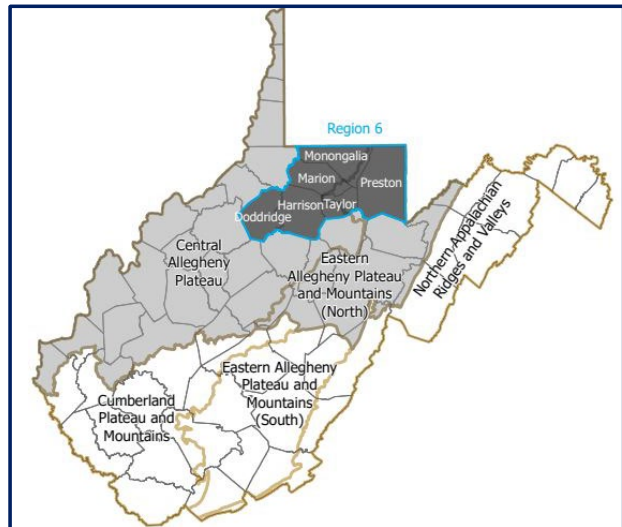
Following is the methodology for landslide susceptibility grids generated using the Random Forest machine learning model:

Landslide locations were mapped throughout West Virginia using light detection and ranging (LiDAR) elevation data products, including [hillshades](#) and [slopes](#). Mapped failure types include slide, debris flow, lateral spread, multiple failures (when several failures were present in a small area, but were too small or close together to map separately), fall, and undetermined failure type (Figure 7). Site characteristics and terrain variables, such as slope, lithology, soil type, and distance to roads and streams, were extracted from the mapped landslide locations. Using a random forest machine learning algorithm, these variables were used as inputs to calculate a probabilistic landslide susceptibility grid. A majority of the mapped landslide locations were used to train the model, and the remaining locations were used to validate the model's accuracy. The resulting grid cells were classified into low, medium, and high susceptibility areas using professional judgement and model statistics. On an average, over 95% of known failure locations were found to occur within the modeled high susceptibility areas ([Maxwell et al., 2020](#)).



**Figure 7.** A) Slide B) Debris Flow C) Lateral Spread D) Multiple Failures E) Fall F) Undetermined

Landslide susceptibility modeling was performed at the [Major Land Resource Area](#) (MLRA) scale. MLRAs are geographic areas defined by the Natural Resources Conservation Service based upon shared characteristics, such as lithology, climate, soils, land uses, and water resources. There are four major MLRAs in West Virginia. Models were generated for each MLRA to take advantage of similarities in physiographic conditions that may influence landslide susceptibility. Two MLRAs are present in Region 6: the **Central Allegheny Plateau** and the northern portion of the **Eastern Allegheny Plateau and Mountains** (Figure 8). The Central Allegheny Plateau MLRA covers all of Doddridge and Harrison counties, most of Marion and Monongalia counties, and the southwest portion of Taylor County. The Eastern Allegheny Plateau and Mountains MLRA covers all of Preston County, northern and eastern Taylor County, and small portions of eastern Monongalia and Marion counties.



**Figure 8.** Major land resource areas in West Virginia



Many local factors contribute to landslides and their related losses. Contributing factors can be natural or human induced, but slope and local bedrock geology strongly influences county and community scale landslide incidence. Bedrock control on landslides is relatively consistent throughout individual MLRAs, which are geographically associated with [Land Resource Units](#) (LRUs).

The following paragraphs present MLRA characteristics for Region 6 and a summary of the critical underlying variables that affect landslide susceptibility in this region. A detailed report on these variables can be found [here](#).

### Landscape Characteristics

Region 6 is situated in an area dominated by rugged topography, clastic sedimentary bedrock, and well-drained soils formed in residuum (material weathered in place or nearly in place) and colluvium (material transported some distance by gravitational processes). Residuum depth varies with rock type and degree of weathering; most rock types in the area produce thin residual soils, but limestone units throughout the area and sandstones on stable low-relief upland surfaces typically develop thick residual soils. Colluvium, which includes landslide deposits, is generally thin close to mountain tops and ridge lines, increasing in thickness farther downslope. Lenses of thick colluvium may accumulate in hillslope hollows, directly upslope from the beginnings of ephemeral stream channels. Mining regolith, unconsolidated material produced as a result of coal extraction, is locally extensive within coal-bearing bedrock units and adjacent terrain.

### Landslide Characteristics and Contributing Factors

**Slides** and **slumps** are the most common landslide types in the region. They tend to develop when soil moisture and pore pressure are highest. *They are most problematic after prolonged wet seasons, particularly in late winter and early spring when soils are saturated and ground-water tables usually are high.* Debris flows initiate as slumps or slides in residuum or colluvium on upper slopes, but may run considerable distances downslope from their source. The most frequent cause of debris flows is heavy rain associated with intense spring and summer storms or late summer and early autumn remnants of tropical cyclones. The high-intensity rainfall events that trigger debris flows tend to produce numerous slope failures in local clusters. Fortunately, large debris flows are uncommon in the region, and they are infrequent even at the most vulnerable Appalachian sites, with recurrence intervals estimated to be hundreds or thousands of years. Rock fall failures are commonly reported in the region, especially on disturbed slopes such as rock cuts along transportation corridors and mine highwalls, but the scope of rock fall susceptibility is not well shown by this landslide inventory. Less common landslide types in the region include multiple failures (tight clusters of small landslides and debris flows that tend to occur during debris flow events) and lateral spreads (clusters of large rock blocks that appear to move rarely).

**Slope:** Analysis of the LiDAR-based landslide data from West Virginia reveals that slope steepness may be the most important control over where landslides develop, especially in steep hillslope hollows that allow subsurface moisture, surface-water runoff, and unconsolidated material to accumulate. The slopes on upland surfaces where slides (including slumps) and debris flows initiate are significantly steeper than most of the nearby landscape. **In the Central Allegheny Plateau, eighty percent of slides and slumps initiated on slopes between 17° to 39° and eighty percent of debris flows initiated on slopes between 14° to 40°. In the northern portion of the Eastern Allegheny Plateau and Mountains, about**



**eighty percent of slides and slumps initiated on slopes of 21° to 40°, while about eighty percent of debris flows initiated on slopes of 17° to 46°.**

**Geology:** Geology is a universally cited factor in landslide distribution, and this is the case for Region 6. The role of geology on landslides may be complex and indirect. Bedrock units heavily dominated by sandstone, the hardest and most resistant rock type in the region, generally are responsible for the highest-elevation topography in the region. The inherent strength of thick sandstones makes them more stable than other rocks at any given slope angle. Weaker bedrock units containing significant amounts of shale and siltstone tend to be more deeply incised and more prone to failure than resistant units, even if the weaker units contain some sandstone beds.

**Soil:** Analysis of mapped landslides and the digital NRCS Soil Survey Geographic database (SSURGO) indicate soil parent material and drainage class correlate with landslide susceptibility in West Virginia. Over 90 percent of slides in the region were mapped in residuum developed from clastic sedimentary bedrock or in colluvium, parent materials that cover over 87 percent of the mapped area. However, mining regolith is the most slide-prone parent material in the region.

In the Central Allegheny Plateau, soil polygons assigned as “well drained” cover over 90 percent of mapped portions of the MLRA, account for almost 97 percent of slide initiation points, and have the highest landslide susceptibility. In the Eastern Allegheny Plateau and Mountains, soil polygons assigned as “well drained” cover about 67 percent of the mapped area, account for almost 82 percent of landslide initiation points, and have the second highest landslide susceptibility. “Excessively drained” soils cover 10 percent of the area, contain the second highest number of landslides, and have the highest landslide susceptibility. “Well drained” and “excessively drained” soil classes commonly occur on steep slopes, so their over-representation in number of slides may reflect a key role of slope as a control of both soil drainage and landslide initiation.

**Other Landslide Factors:** Although many factors influencing slope stability are universal, some aspects of slope stability in Region 6 differ from other areas in West Virginia. Anthropogenic disturbance is significant, especially in urban areas and landscapes underlain by or adjacent to coal-bearing bedrock. Urban and rural development has long been known to enhance landslide susceptibility in West Virginia. Hillslopes underlain by weak bedrock or soil may obtain a significant fraction of their shear strength from tree roots, so intensive clearing for timber harvesting or real estate development may lessen slope strength. Ill-designed or poorly constructed roadways, commercial sites, and housing developments may lead to surface drainage disruptions that cause unprecedented soil saturation and abnormal slope destabilization. The importance of good engineering design, based on slope-stability site analysis by professional geologists and certified civil engineers, cannot be over-emphasized. Neither can the importance of long-term monitoring and maintenance of constructed drainage and retaining structures.

**Landslide Susceptibility E-size maps** for Doddridge, Harrison, Marion, Monongalia, Preston, & Taylor counties can be viewed [here](#).

## Risk Assessment

The following datasets have been used in risk assessment study for roads and structures/parcels

- Landslide susceptibility analyses using random forest machine learning algorithms and landslide occurrence locations ([Maxwell et al., 2020](#))
- E-911 site address points inside the floodplain
- Parcel centroids for areas outside the floodplain
- Roads (accessed from WV DOH [website](#))

## Risk Analysis

### Roads

Road risk analysis provides an assessment of landslide risk along roads in West Virginia. **This analysis is suitable only for planning level analysis and should be used in conjunction with site-specific risk analysis performed by WV Department of Transportation.** This “big picture” perspective will benefit the planning of route improvements and lead to more effective landslide risk mitigation for West Virginia roads. The analysis classifies roads into high, medium, and low risk areas. The following methodology was used to assess landslide risk to roads in Region 6.

The statewide landslide susceptibility grid was classified as High (1-0.7), Medium (< 0.7-0.3), and Low (0.3-0) susceptibility. This raster grid was then converted to a vector feature class. Road data from [WV Department of Transportation](#) was used for analysis. For analysis, roads were analyzed for Interstate, US Roads, State, and Other roads (county roads, N/A, state parks, and forests road, FANS, HARP, and Others). Municipal non-state roads, railroads, and trail features were not included in the analysis. Since the road feature class is a line layer, a buffer of four meters was created for the road feature class. A buffer was created to adequately capture the risk for the road feature class as most landslides initiate on the side slopes of roads. An intersection between the buffered road layer and the susceptibility feature class was performed to capture risk information for road segments that overlapped with high and medium susceptibility areas. Finally, the road layer was clipped using the buffer layer to identify high and medium risk road segments for each community.

### Results:

Roads were analyzed at two scales. An overview level analysis was performed on all of the roads without any distinction to get the total risk to the roads in each community. This result was used to rank communities based on the length of susceptible roads. The second set of analyses contains susceptibility details relating to Interstates, US Roads, State Roads, and Others. Railroads and trails were not part of the analysis.

Table 1 shows the total miles of road that are prone to high/medium slope failure risk. The table also shows the rank of landslide susceptibility within the state. **Doddridge County** has almost 75 miles of road that is susceptible to high/medium probability of landslides. **Harrison County** has 109 miles,

**Marion County** has about 140 miles, **Monongalia County** has 132 miles, **Preston County** has almost 173 miles, and **Taylor County** has about 72 miles of road prone to high/medium risk for slope failure. Counties were ranked for slope failure risk based on the number of miles that are at risk. **Three Region 6 counties fall in the Top 10 for highest number of road miles at risk.** Of all 55 counties, Doddridge ranks 29<sup>th</sup>, Harrison 13<sup>th</sup>, **Marion 7<sup>th</sup>**, **Monongalia 8<sup>th</sup>**, **Preston 2<sup>nd</sup>**, and Taylor 30<sup>th</sup>. Most of the at-risk roads are in the unincorporated areas of each county. Figure 9 shows an example of landslide risk along WV-72 near Rowlesburg, WV in Preston County. The road segments susceptible to landslide can be viewed on the [Landslide Tool](#).



# WEST VIRGINIA LANDSLIDE RISK ASSESSMENT- REGION 6

**Table 1.** Road length susceptible to High/Medium Risk of Landslide

Community Name	County	Roads Total (miles)	Roads Total (miles)- High/Medium Risk	Rank <sup>1</sup>
Doddridge County*	DODDRIDGE	563.6	74.4	29
West Union	DODDRIDGE	3	0.2	127
	<b>DODDRIDGE</b>	<b>566.6</b>	<b>74.6</b>	<b>29</b>
Anmoore	HARRISON	6.9	0.3	100
Bridgeport	HARRISON	61.6	2.8	12
Clarksburg	HARRISON	60.2	5.1	5
Harrison County*	HARRISON	857.5	97.8	18
Lost Creek	HARRISON	9.7	0.4	85
Lumberport	HARRISON	3.8	0.3	100
Nutter Fort	HARRISON	3.8	0.3	100
Salem	HARRISON	6.7	0.8	47
Shinnston	HARRISON	8.6	0.8	47
Stonewood	HARRISON	3.9	0.2	127
West Milford	HARRISON	4.6	0.2	127
	<b>HARRISON</b>	<b>1027.3</b>	<b>109</b>	<b>13</b>
Barrackville	MARION	5.4	0.5	68
Fairmont	MARION	50.1	3.9	7
Fairview	MARION	3	0.3	100
Farmington	MARION	4.4	0.7	57
Grant	MARION	3.4	0.2	127
Mannington	MARION	8	0.9	42
Marion County*	MARION	724.7	125.8	8
Monongah	MARION	4.9	0.8	47
Pleasant Valley	MARION	28.4	2.5	16
Rivesville	MARION	8.3	0.3	100
White Hall	MARION	11.9	0.6	63
Worthington	MARION	2	0.2	127
	<b>MARION</b>	<b>854.5</b>	<b>136.7</b>	<b>7</b>
Blacksville	MONONGALIA	2.4	0.2	127
Granville	MONONGALIA	5.2	0.4	85
Monongalia County*	MONONGALIA	915.9	123.3	9
Morgantown	MONONGALIA	62.3	7	4
Star City	MONONGALIA	3.8	0.2	127
Westover	MONONGALIA	11.4	0.9	42
	<b>MONONGALIA</b>	<b>1001</b>	<b>132</b>	<b>8</b>
Albright	PRESTON	2.3	0.3	100
Brandonville	PRESTON	2	0	189
Bruceton Mills	PRESTON	0.4	0	189
Kingwood	PRESTON	11.7	0.4	85
Masontown	PRESTON	3.3	0.2	127
Newburg	PRESTON	4	1.1	36
Preston County*	PRESTON	1266.9	169.2	2
Reedsville	PRESTON	2.1	0	189
Rowlesburg	PRESTON	4.6	0.8	47
Terra Alta	PRESTON	12.4	0.5	68
Tunnelton	PRESTON	2.6	0.3	100
	<b>PRESTON</b>	<b>1312.3</b>	<b>172.8</b>	<b>2</b>
Flemington	TAYLOR	4.8	0.5	68
Grafton	TAYLOR	30.5	4.9	6
Taylor County*	TAYLOR	430.2	66.2	32
	<b>TAYLOR</b>	<b>465.5</b>	<b>71.6</b>	<b>30</b>

\* Unincorporated

<sup>1</sup> Group Rank on Community Type: County, Unincorporated, Incorporated



**Figure 9.** Landslide Susceptibility near Rowlesburg, WV in Preston County. Notice high and medium landslide susceptibility areas along WV-72. Data can be accessed on [WV Flood Tool](#)

The second set of risk analyses was performed to evaluate the total length of different types of roads in high/medium susceptible areas in each community. Table 2 shows details of different types of roads in high/medium susceptibility zones in each community. In each county, most of the at-risk roads are in the unincorporated areas. In **Doddridge County**, the unincorporated area has 74.4 miles of at-risk roads, constituting over 99% of at-risk roads in the county; 3.1 miles of US roads and 3.6 miles of State roads are at risk. West Union has 0.2 miles of at-risk roads. There are no Interstate roads at risk in Doddridge County. **Harrison County** has 97.8 miles of at-risk roads in unincorporated areas, constituting almost 90% of at-risk roads in the county. Unincorporated areas have 1.5 miles of Interstate roads, 5.3 miles of US roads at risk, and 3.6 miles of State roads at risk. Bridgeport has 2.8 miles of at-risk roads. Clarksburg has 5.1 miles of at-risk roads and ranks 5<sup>th</sup> among incorporated communities for highest number of road miles at risk. The remaining communities each have less than 1 mile of roads at risk. **Marion County** has 125.8 miles of at-risk roads in unincorporated areas, accounting for 92% of at-risk roads in the county. Unincorporated areas have 1.7 miles of Interstate roads, 13.8 miles of US roads, and 2.9 miles of State roads at risk. Fairmont has 3.9 miles of at-risk roads and Pleasant Valley has 2.5 miles. The remaining communities each have less than 1 mile of roads at risk. **Monongalia County** has 123.3 miles of at-risk roads in unincorporated areas, constituting about 93% of at-risk roads in the county. The unincorporated area has 4.4 miles of Interstate roads, 10.7 miles of US roads, and 7.6 miles of State roads at risk. Morgantown has 7 miles of at-risk roads and ranks 4<sup>th</sup> among incorporated communities for highest number of road miles at risk. The remaining communities each have less than 1 mile of at-risk roads. **Preston County** has 169.2 miles of at-risk roads in unincorporated areas, constituting almost 98% of at-risk roads in the county. The unincorporated areas have 2.1 miles of Interstate roads, 21.3 miles of US roads, and 19.5 miles of State roads at risk. Newburg has 1.1 miles of at-risk roads and the

# WEST VIRGINIA LANDSLIDE RISK ASSESSMENT- REGION 6

remaining communities each have less than 1 mile of roads at risk. There are no at-risk roads in Brandonville, Bruceton Mills, or Reedsville. **Taylor County** has 66.2 miles of roads at risk in unincorporated areas, accounting for 92% of at-risk roads in the county. Unincorporated areas have 17.8 miles of US roads and 1.9 miles of State roads at risk. Grafton has 4.9 miles of at-risk roads and Flemington has 0.5 miles. There are no Interstate roads at risk in Taylor County.

**Table 2.** Different road type and length susceptible to High/Medium Risk of Landslide

Community Name	County	Roads Total (miles)	Roads Total (miles)- High/Medium Risk	Interstate Roads High/Medium Risk	US Roads High/Medium Risk	State Roads High/Medium Risk	Other Roads
Doddridge County*	DODDRIDGE	563.6	74.4	0	3.1	3.6	67.8
West Union	DODDRIDGE	3	0.2	0	0	0.1	0.1
	<b>DODDRIDGE</b>	<b>566.6</b>	<b>74.6</b>	<b>0</b>	<b>3.1</b>	<b>3.7</b>	<b>67.9</b>
Anmoore	HARRISON	6.9	0.3	0.2	0	0	0.1
Bridgeport	HARRISON	61.6	2.8	0.4	0.2	0.7	1.5
Clarksburg	HARRISON	60.2	5.1	0.1	1.8	0.2	3
Harrison County*	HARRISON	857.5	97.8	1.5	5.3	3.6	87.2
Lost Creek	HARRISON	9.7	0.4	0.2	0	0.1	0.1
Lumberport	HARRISON	3.8	0.3	0	0	0.2	0.2
Nutter Fort	HARRISON	3.8	0.3	0	0	0.1	0.2
Salem	HARRISON	6.7	0.8	0	0	0	0.8
Shinnston	HARRISON	8.6	0.8	0	0.2	0.3	0.4
Stonewood	HARRISON	3.9	0.2	0	0	0.1	0.2
West Milford	HARRISON	4.6	0.2	0	0	0	0.2
	<b>HARRISON</b>	<b>1027.3</b>	<b>109</b>	<b>2.4</b>	<b>7.5</b>	<b>5.3</b>	<b>93.9</b>
Barrackville	MARION	5.4	0.5	0	0.2	0	0.4
Fairmont	MARION	50.1	3.9	0.1	1.2	0.2	2.4
Fairview	MARION	3	0.3	0	0	0.1	0.2
Farmington	MARION	4.4	0.7	0	0.2	0.3	0.2
Grant	MARION	3.4	0.2	0	0	0	0.2
Mannington	MARION	8	0.9	0	0.9	0	0
Marion County*	MARION	724.7	125.8	1.7	13.8	2.9	107.3
Monongah	MARION	4.9	0.8	0	0	0	0.8
Pleasant Valley	MARION	28.4	2.5	1.3	0	0.2	1
Rivesville	MARION	8.3	0.3	0	0	0	0.3
White Hall	MARION	11.9	0.6	0.1	0.2	0	0.3
Worthington	MARION	2	0.2	0	0.2	0	0
	<b>MARION</b>	<b>854.5</b>	<b>136.7</b>	<b>3.2</b>	<b>16.7</b>	<b>3.7</b>	<b>113.1</b>
Blacksville	MONONGALIA	2.4	0.2	0	0	0	0.1
Granville	MONONGALIA	5.2	0.4	0.1	0.1	0.1	0.2
Monongalia County*	MONONGALIA	915.9	123.3	4.4	10.7	7.6	100.5
Morgantown	MONONGALIA	62.3	7	0.1	2.9	0.3	3.6
Star City	MONONGALIA	3.8	0.2	0	0.1	0	0.1
Westover	MONONGALIA	11.4	0.9	0	0.4	0	0.5
	<b>MONONGALIA</b>	<b>1001</b>	<b>132</b>	<b>4.6</b>	<b>14.2</b>	<b>8</b>	<b>105</b>
Albright	PRESTON	2.3	0.3	0	0	0	0.3
Brandonville	PRESTON	2	0	0	0	0	0



Bruceton Mills	PRESTON	0.4	0	0	0	0	0
Kingwood	PRESTON	11.7	0.4	0	0	0.3	0.1
Masontown	PRESTON	3.3	0.2	0	0	0	0.2
Newburg	PRESTON	4	1.1	0	0	0.4	0.6
Preston County*	PRESTON	1266.9	169.2	2.1	21.3	19.5	126.2
Reedsville	PRESTON	2.1	0	0	0	0	0
Rowlesburg	PRESTON	4.6	0.8	0	0	0.3	0.6
Terra Alta	PRESTON	12.4	0.5	0	0	0	0.5
Tunnelton	PRESTON	2.6	0.3	0	0	0	0.2
	<b>PRESTON</b>	<b>1312.3</b>	<b>172.8</b>	<b>2.1</b>	<b>21.3</b>	<b>20.5</b>	<b>128.7</b>
Flemington	TAYLOR	4.8	0.5	0	0	0	0.5
Grafton	TAYLOR	30.5	4.9	0	3	0	1.9
Taylor County*	TAYLOR	430.2	66.2	0	17.8	1.9	46.5
	<b>TAYLOR</b>	<b>465.5</b>	<b>71.6</b>	<b>0</b>	<b>20.8</b>	<b>1.9</b>	<b>48.9</b>

\* Unincorporated

## Land Use Landslide Risk

Land use risk analysis provides an assessment of landslide risk to structures/parcels in West Virginia. **This study is not intended for site-specific analysis or remediation measures and is only suitable for planning-level analysis.** This “big picture” perspective will benefit planning and lead to more effective landslide risk mitigation for West Virginia. The following methodology was used to assess landslide risk to structures/parcels.

Primary structures were extracted for each parcel both inside and outside of the 1% annual chance floodplain in each community. Verified primary structures located inside the 1% annual chance floodplain were used as a point to assess landslide risk within a parcel. For primary structures outside of the floodplain, the following methodology was applied to extract primary structures. This method was used to avoid overestimating the values for each parcel. A spatial join was performed between the site address point and property tax assessment record. To avoid overestimating the appraisal value, the average was calculated by dividing the building appraisal value of the tax assessment record by the number of points located in the parcel. A spatial join was performed between the site addresses and parcels with the average building appraisal value. The output resulted in a site address point feature class representing primary structures attributed to the building appraisal value. These processing steps avoided adding the same building appraisal value multiple times to more than one site address point within a tax parcel.

One notable limitation of this method was that parcels containing no addressing points are assigned a building value of zero (\$0). In addition, the building values for some structures are less than the values recorded in the community-wide building dollar exposure report because for specific parcels the appraisal values may be in neighboring parcels instead of the parcel where the structure is located. This results in building values not being assigned to site address points. Also, some government and other property values do not get pulled in from the statewide assessment database, resulting in lower value of at-risk structures.

## Results:

Structures were analyzed at two scales for each community. An initial overview-level analysis was performed for all of the structures without any distinction to occupancy type. A second analysis was performed for different types of occupancy for high/medium risk of landslide.

Table 3 shows the total count of primary structures in high/medium landslide susceptibility areas. Total asset values were then derived from the 2021 tax assessment database. Each county was ranked for the number of primary structures and the total asset values in high/medium susceptibility areas. **Doddridge County** has a total of 178 primary structures with a total appraisal value of \$6,739,115 that are in high/medium susceptibility areas. **Harrison County** has 1,069 primary structures with a total appraisal value of \$256,888,640 in high/medium susceptibility areas. **Marion County** has 941 primary structures with a total appraisal value of \$71,733,187 in high/medium susceptibility areas. **Monongalia County** has a total of 2,967 primary structures with a total appraisal value of \$344,409,948 that are in high/medium susceptibility areas. **Preston County** has 277 primary structures with a total appraisal value of \$32,450,262 in high/medium susceptibility areas. **Taylor County** has 373 primary structures with a total appraisal value of \$13,436,410 in high/medium susceptibility areas. **Three Region 6 counties rank in the Top 10 for both total structure count and total asset value in high/medium landslide risk areas in the state.** For total count of at-risk structures, Doddridge ranks 47<sup>th</sup>, **Harrison 4<sup>th</sup>**, **Marion 6<sup>th</sup>**, **Monongalia 2<sup>nd</sup>**, Preston 37<sup>th</sup>, and Taylor 24<sup>th</sup>. For total asset value, Doddridge ranks 40<sup>th</sup>, **Harrison 3<sup>rd</sup>**, **Marion 5<sup>th</sup>**, **Monongalia 2<sup>nd</sup>**, Preston 12<sup>th</sup>, and Taylor 26<sup>th</sup>.

# WEST VIRGINIA LANDSLIDE RISK ASSESSMENT- REGION 6

**Table 3. Structures with High/Medium Risk Landslide Susceptibility**

Community Name	County	Total Count	Total Value	Ranking(Count) <sup>1</sup>	Ranking(Value) <sup>1</sup>
Doddridge County*	DODDRIDGE	154	\$6,175,515	45	35
West Union	DODDRIDGE	24	\$563,600	53	69
	<b>DODDRIDGE</b>	<b>178</b>	<b>\$6,739,115</b>	<b>47</b>	<b>40</b>
Anmoore	HARRISON	12	\$363,477	85	88
Bridgeport	HARRISON	89	\$210,930,574	19	1
Clarksburg	HARRISON	291	\$11,394,337	7	10
Harrison County*	HARRISON	562	\$30,699,802	6	8
Lost Creek	HARRISON	9	\$129,300	104	128
Lumberport	HARRISON	5	\$35,500	129	173
Nutter Fort	HARRISON	11	\$415,800	89	83
Salem	HARRISON	54	\$1,487,100	30	43
Shinnston	HARRISON	17	\$563,300	69	70
Stonewood	HARRISON	17	\$817,450	69	55
West Milford	HARRISON	2	\$52,000	164	163
	<b>HARRISON</b>	<b>1069</b>	<b>\$256,888,640</b>	<b>4</b>	<b>3</b>
Barrackville	MARION	19	\$617,100	61	64
Fairmont	MARION	380	\$41,299,250	6	5
Fairview	MARION	0	\$0	195	191
Farmington	MARION	1	\$26,000	178	181
Grant	MARION	2	\$222,200	164	103
Mannington	MARION	20	\$493,400	57	76
Marion County*	MARION	460	\$25,785,837	12	14
Monongah	MARION	9	\$544,800	104	72
Pleasant Valley	MARION	30	\$888,800	47	52
Rivesville	MARION	4	\$219,300	139	106
White Hall	MARION	6	\$1,182,700	123	47
Worthington	MARION	10	\$453,800	94	81
	<b>MARION</b>	<b>941</b>	<b>\$71,733,187</b>	<b>6</b>	<b>5</b>
Blacksville	MONONGALIA	4	\$67,000	139	151
Granville	MONONGALIA	230	\$38,071,830	11	7
Monongalia County*	MONONGALIA	1746	\$175,035,772	2	1
Morgantown	MONONGALIA	919	\$127,624,502	2	3
Star City	MONONGALIA	10	\$468,975	94	78
Westover	MONONGALIA	58	\$3,141,869	29	22
	<b>MONONGALIA</b>	<b>2967</b>	<b>\$344,409,948</b>	<b>2</b>	<b>2</b>
Albright	PRESTON	2	\$0	164	191
Brandonville	PRESTON	0	\$0	195	191
Bruceton Mills	PRESTON	0	\$0	195	191
Kingwood	PRESTON	10	\$832,450	94	54
Masontown	PRESTON	12	\$249,050	85	98
Newburg	PRESTON	8	\$114,600	111	134
Preston County*	PRESTON	209	\$30,436,362	35	9
Reedsville	PRESTON	2	\$46,700	164	167
Rowlesburg	PRESTON	19	\$455,600	61	80
Terra Alta	PRESTON	10	\$144,100	94	123
Tunnelton	PRESTON	5	\$171,400	129	113
	<b>PRESTON</b>	<b>277</b>	<b>\$32,450,262</b>	<b>37</b>	<b>12</b>
Flemington	TAYLOR	0	\$0	195	191
Grafton	TAYLOR	234	\$5,307,867	10	16
Taylor County*	TAYLOR	139	\$8,128,543	46	29
	<b>TAYLOR</b>	<b>373</b>	<b>\$13,436,410</b>	<b>24</b>	<b>26</b>

\* Unincorporated

<sup>1</sup> Group Rank on Community Type: County, Unincorporated, Incorporated



Table 4 shows detailed risk of slope failure based on different occupancy classes. For most Region 6 counties, the **Residential** occupancy class has the highest structure counts and total replacement costs in high/medium landslide susceptibility areas. Harrison County is the exception, where the Commercial occupancy class accounts for the highest total replacement costs. Replacement costs for the Other occupancy class should be ignored as some government and other property values do not get incorporated in the statewide assessment database, resulting in lower value of at-risk structures.

**Doddridge County** has 94 structures in the Residential occupancy class with replacement costs of \$3,132,863, followed by 74 Other structures, and 10 Commercial structures with a total replacement cost of \$2,050,800. The unincorporated areas have the highest structure counts and corresponding replacement costs in all occupancy classes.

**Harrison County** has a total of 827 structures in the Residential occupancy class with replacement costs of \$68,026,655, followed by 199 Other structures, and 43 Commercial structures with replacement costs of \$185,197,580. The unincorporated area has the highest structure count in all occupancy classes and the highest replacement costs for the Residential class. However, Bridgeport has the highest replacement costs in the Commercial class, making up 97% of the total at-risk Commercial asset value in the county while only accounting for 23% of the Commercial structure count.

**Marion County** has a total of 791 structures in the Residential occupancy class with replacement costs of \$44,799,820, followed by 124 Other structures, and 26 Commercial structures with replacement costs of \$24,469,400. The unincorporated area has the highest structure count and corresponding replacement costs in the Residential and Other occupancy classes, while Fairmont has the highest structure count and replacement costs in the Commercial class. There are no at-risk structures in Fairview.

**Monongalia County** has a total of 2,438 structures in the Residential occupancy class with replacement costs of \$231,493,444, followed by 388 Other structures, and 141 Commercial structures with replacement costs of \$37,165,612. The unincorporated area has the highest structure count and corresponding replacement costs in the Residential and Commercial occupancy classes, while Morgantown has the highest replacement costs in the Other occupancy class.

**Preston County** has a total of 193 structures in the Residential occupancy class with replacement costs of \$8,105,992, followed by 76 Other structures, and 8 Commercial structures with replacement costs of \$477,650. The unincorporated area has the highest structure count and corresponding replacement costs in the Residential and Other occupancy classes, while Kingwood has the highest structure count and replacement costs in the Commercial class. There are no at-risk structures in Brandonville or Bruceton Mills.

**Taylor County** has a total of 294 structures in the Residential occupancy class with replacement costs of \$11,853,135, followed by 69 Other structures, and 10 Commercial structures with replacement costs of \$97,267. Grafton has the highest structure count in all occupancy classes and the highest replacement costs in the Commercial class. However, the unincorporated area has the highest replacement costs in the Residential class, making up 60% of the total at-risk Residential asset value in the county while only accounting for 35% of the Residential structure count. There are no at-risk structures in Flemington.

# WEST VIRGINIA LANDSLIDE RISK ASSESSMENT- REGION 6

**Table 4. Types of Structures with High/Medium Risk Landslide Susceptibility**

Community Name	County	RESIDENTIAL OCCUPANCY CLASS		COMMERCIAL OCCUPANCY CLASS		OTHER OCCUPANCY CLASS	
		High/Medium Susceptibility		High/Medium Susceptibility		High/Medium Susceptibility	
		Residential count	Residential value	Commercial count	Commercial value	Other count	Other value**
Doddridge County*	DODDRIDGE	77	\$2,597,963	7	\$2,027,800	70	\$1,549,752
West Union	DODDRIDGE	17	\$534,900	3	\$23,000	4	\$5,700
	<b>DODDRIDGE</b>	<b>94</b>	<b>\$3,132,863</b>	<b>10</b>	<b>\$2,050,800</b>	<b>74</b>	<b>\$1,555,452</b>
Anmoore	HARRISON	10	\$291,237	2	\$72,240	0	\$0
Bridgeport	HARRISON	74	\$30,974,274	10	\$179,880,200	5	\$76,100
Clarksburg	HARRISON	254	\$10,740,017	10	\$319,720	27	\$334,600
Harrison County*	HARRISON	388	\$22,575,477	17	\$4,872,220	157	\$3,252,105
Lost Creek	HARRISON	8	\$129,300	0	\$0	1	\$0
Lumberport	HARRISON	3	\$35,500	0	\$0	2	\$0
Nutter Fort	HARRISON	10	\$398,800	1	\$17,000	0	\$0
Salem	HARRISON	49	\$1,485,500	1	\$0	4	\$1,600
Shinnston	HARRISON	15	\$527,100	2	\$36,200	0	\$0
Stonewood	HARRISON	14	\$817,450	0	\$0	3	\$0
West Milford	HARRISON	2	\$52,000	0	\$0	0	\$0
	<b>HARRISON</b>	<b>827</b>	<b>\$68,026,655</b>	<b>43</b>	<b>\$185,197,580</b>	<b>199</b>	<b>\$3,664,405</b>
Barrackville	MARION	17	\$496,900	0	\$0	2	\$120,200
Fairmont	MARION	324	\$16,943,650	14	\$23,322,300	42	\$1,033,300
Fairview	MARION	0	\$0	0	\$0	0	\$0
Farmington	MARION	1	\$26,000	0	\$0	0	\$0
Grant	MARION	2	\$222,200	0	\$0	0	\$0
Mannington	MARION	18	\$493,400	0	\$0	2	\$0
Marion County*	MARION	378	\$24,027,070	8	\$448,300	74	\$1,310,467
Monongah	MARION	9	\$544,800	0	\$0	0	\$0
Pleasant Valley	MARION	25	\$884,400	1	\$4,400	4	\$0
Rivesville	MARION	4	\$219,300	0	\$0	0	\$0
White Hall	MARION	3	\$488,300	3	\$694,400	0	\$0
Worthington	MARION	10	\$453,800	0	\$0	0	\$0
	<b>MARION</b>	<b>791</b>	<b>\$44,799,820</b>	<b>26</b>	<b>\$24,469,400</b>	<b>124</b>	<b>\$2,463,967</b>
Blacksville	MONONGALIA	3	\$67,000	0	\$0	1	\$0
Granville	MONONGALIA	208	\$23,760,123	22	\$14,311,707	0	\$0
Monongalia County*	MONONGALIA	1439	\$150,444,629	92	\$18,545,350	215	\$6,045,792
Morgantown	MONONGALIA	728	\$53,944,127	22	\$3,993,475	169	\$69,686,900
Star City	MONONGALIA	9	\$468,175	1	\$800	0	\$0
Westover	MONONGALIA	51	\$2,809,389	4	\$314,280	3	\$18,200
	<b>MONONGALIA</b>	<b>2438</b>	<b>\$231,493,444</b>	<b>141</b>	<b>\$37,165,612</b>	<b>388</b>	<b>\$75,750,892</b>
Albright	PRESTON	1	\$0	0	\$0	1	\$0
Brandonville	PRESTON	0	\$0	0	\$0	0	\$0
Bruceton Mills	PRESTON	0	\$0	0	\$0	0	\$0
Kingwood	PRESTON	7	\$493,400	3	\$339,050	0	\$0
Masontown	PRESTON	8	\$247,050	1	\$1,000	3	\$1,000
Newburg	PRESTON	7	\$114,600	0	\$0	1	\$0
Preston County*	PRESTON	146	\$6,591,142	2	\$71,200	61	\$23,774,021

# WEST VIRGINIA LANDSLIDE RISK ASSESSMENT- REGION 6

Reedsville	PRESTON	1	\$36,900	0	\$0	1	\$9,800
Rowlesburg	PRESTON	15	\$433,900	0	\$0	4	\$21,700
Terra Alta	PRESTON	6	\$142,700	1	\$1,400	3	\$0
Tunnelton	PRESTON	2	\$46,300	1	\$65,000	2	\$60,100
	<b>PRESTON</b>	<b>193</b>	<b>\$8,105,992</b>	<b>8</b>	<b>\$477,650</b>	<b>76</b>	<b>\$23,866,621</b>
Flemington	TAYLOR	0	\$0	0	\$0	0	\$0
Grafton	TAYLOR	191	\$4,707,400	6	\$88,067	37	\$512,400
Taylor County*	TAYLOR	103	\$7,145,735	4	\$9,200	32	\$973,608
	<b>TAYLOR</b>	<b>294</b>	<b>\$11,853,135</b>	<b>10</b>	<b>\$97,267</b>	<b>69</b>	<b>\$1,486,008</b>

\* Unincorporated

\*\*Other occupancy class value is underreported as assessment value may be absent in assessment database.

## Limitations and Expert Consultation

Landslide susceptibility classifications are based on physical characteristics associated with landslide locations mapped using LiDAR data. The nature of the West Virginia landscape and the LiDAR imagery limited mapping to landslides at least 33 feet wide. This approach undercounts small, shallow landslides and slope failures that may have been mitigated or removed by human agents. LiDAR-mapped landslide locations and landslide susceptibility maps derived from this data are inherently biased against these areas. Additionally, it is not feasible to thoroughly verify the accuracy of each dataset used for mapping and modeling. However, every effort has been made to ensure the integrity of this data.

Landslide risk is complex and continually changing. Future mitigation projects or alterations to topography, land use, and climate may render these results inaccurate. Other models, maps, reports, and future site-specific analyses may provide results that differ from those included here.

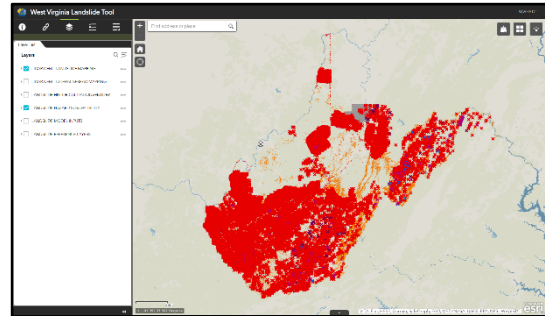
**This study is NOT intended for regulatory use and is NOT the final authoritative source of all landslide risk data in the community. It should be used in conjunction with other data sources to provide a comprehensive picture of general landslide risk. This report is for informational and planning purposes regarding landslide susceptibility and risk at the county scale. It may not be used to identify susceptibility at site-specific locations.**

To address landslide susceptibility at a sub-county scale, geotechnical evaluations should be performed by professional engineers or geologists. For site-specific investigations, local officials, developers, and property owners should consult slope-stability experts, such as certified professional engineers and qualified geologists. Site-specific evaluations for landslide susceptibility can only be provided by performing detailed site-specific geotechnical studies, including bedrock and soil analyses, core description, physical testing, and slope-stability analyses.



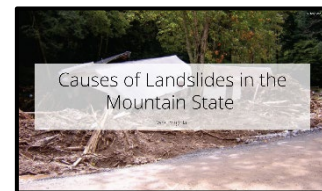
## Outreach Materials

- **The West Virginia Landslide Tool** (<http://mapwv.gov/landslide>) is a landslide web mapping application showing landslide incidence data and modeling results. The West Virginia GIS Technical Center created an ArcGIS online map that provides information about landslide susceptibility and landslides mapped throughout West Virginia. The map allows users to display landslide locations mapped by the West Virginia Department of Transportation (WV DOT), West Virginia Geological and Economic Survey (WVGES), United States Geological Survey (USGS), several independent research projects, and landslides mapped using high-resolution elevation data. The public can also add landslide locations to the West Virginia Landslide Tool (<http://www.mapwv.gov/landslide>) by taking a photo of the landslide and uploading it to the application.



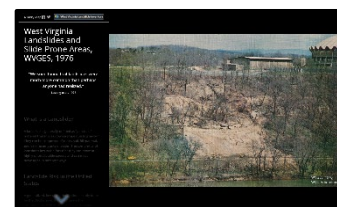
**Figure 10.** [West Virginia Landslide Tool](http://mapwv.gov/landslide)

- **Story Maps**
  - ***Causes of Landslides in Mountain State, West Virginia*** <https://arcg.is/1SW0Sn> discusses different causes of landslides in the state.



**Figure 11.** Story Map showing causes of landslide

- ***West Virginia Landslides and Slide Prone Areas, WVGES 1976*** <https://arcg.is/1KDnvg> discusses landslide risk assessment published in 1976 by the WV Geological and Economic Survey that was funded by the Appalachian Regional Commission.



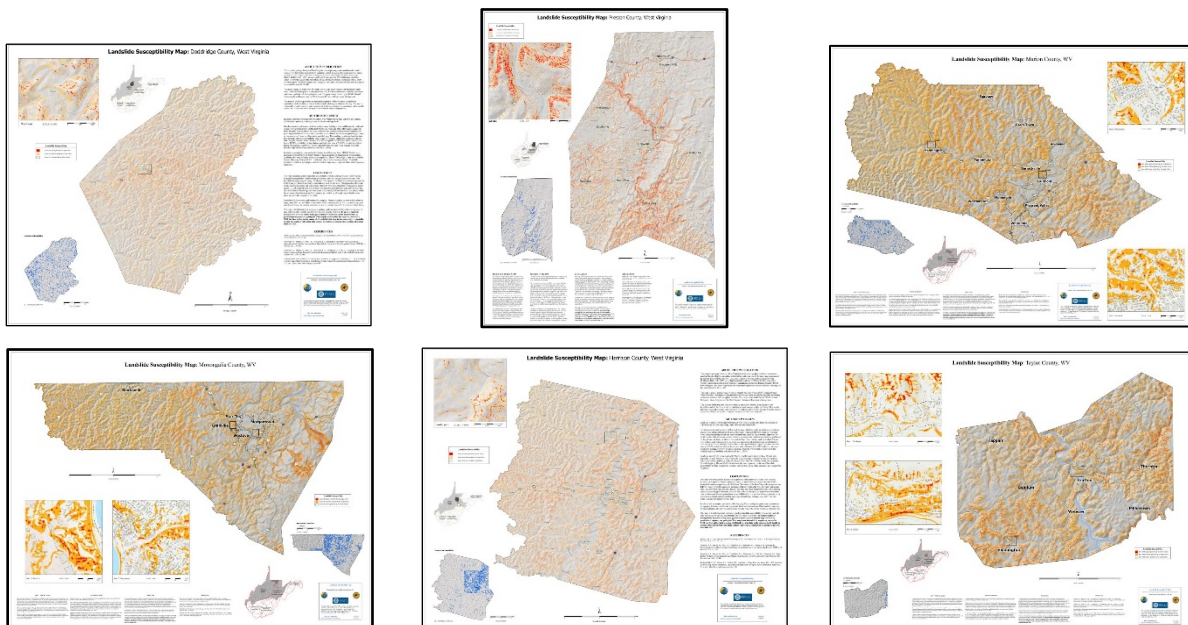
**Figure 12.** WVGES 1976 Study details in Story Map

- **Educational brochures** were developed to provide general information about identifying signs of slope instability and mitigation measures that may help reduce landslide risk at the [community](#) and [individual](#) property levels.



**Figure 13.** Mitigation brochure for community and property owners

- **Landslide susceptibility modelling publications-** Two peer reviewed modelling papers have been published in refereed journals
  - [Slope Failure Prediction Using Random Forest Machine Learning and LiDAR in an Eroded Folded Mountain Belt](#) – Published in journal Remote Sensing
  - [Assessing the Generalization of Machine Learning-Based Slope Failure Prediction to New Geographic Extents](#) – Published in journal International Journal of Geo-Information
- **County Landslide Susceptibility Maps** – Landslide susceptibility maps for Doddridge, Harrison, Marion, Monongalia, Preston, & Taylor counties can be viewed and downloaded [here](#).



**Figure 14.** Landslide Susceptibility maps of Doddridge, Harrison, Marion, Monongalia, Preston, & Taylor counties

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